The Achilles Tear in Parkour:

A Pattern Observed, Solutions Offered

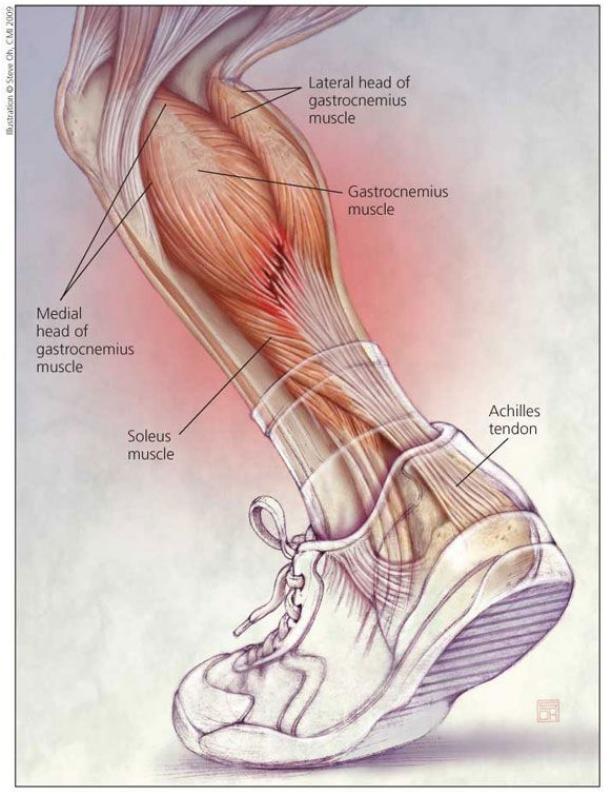

Figure 1. Anatomy of the Lower Leg, featuring the Achilles Tendon and the Muscles of the calf. Adapted from "Chronic Achilles Tendon Injury" by The Hospital for Special Surgery. Copyright 2009 by Steve Oh, CMI

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Abstract

The Achilles tear is a devastating injury, and although it is not common in parkour at the moment, we may see this pattern accelerate due to factors such as a growing demographic of older practitioners and the Achilles put under more and more tension in complex positions as advanced practitioners push human limits. We've taken notice of this injury showing up worldwide and have created solutions for mitigating it in our own coaching practices and curriculum. This paper is not only a chance to share our solutions, but also to further study the pattern through an initial survey of 16 cases. As future cases appear, we will continue to gather and analyze data in order to bring to light more understanding. Through extensive research, data collection, and many years of coaching experience, we have identified several of the contributors to this injury and offer solutions that can be applied as a practitioner, a coach, and a program manager. We believe that applying this knowledge on a large scale worldwide will mitigate the Achilles tear in parkour as the amount of practitioners rapidly grows. We're also pleased to contribute to exercise science in general.

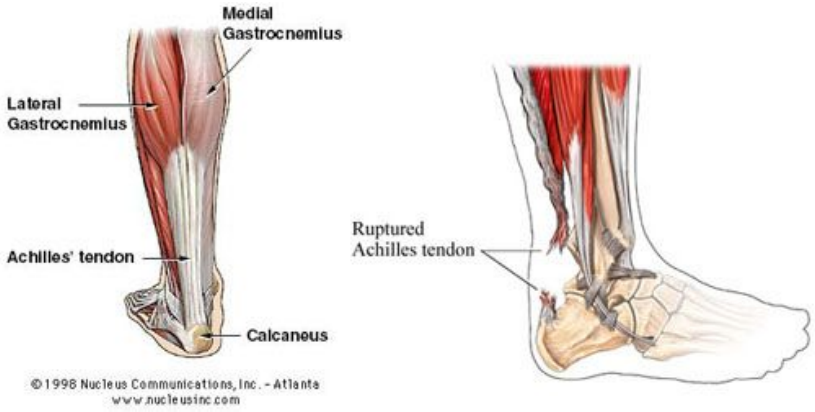

Figure 2. Anatomy of Lower Leg, featuring a Ruptured Achilles Tendon. Adapted from "Achilles Rupture" by the Samimi Orthopaedic Group. Copyright 1998 by Nucleus Communications, Inc.

Achilles tears are devastating injuries that can take 6 to 18 months to recover from even when the injured person is proactive with physical therapy(Rees, Wilson, & Wolman, 2006). Also, there may be a unique challenge for parkour practitioners compared to other sports and arts that don't involve high tension on the Achilles while in the complex positions we see in techniques such as wall runs, tic tacs, cat leaps, and downward strides.

Figure 3. Amos Rendao Demonstrates Examples of High Tension on the Achilles During Complex Positions in Parkour Specific Techniques. (Top Left) Tic Tac.This technique is used to redirect for height, distance, etc. using a vertical surface. (Top Right) Wall Run. This technique is used to get maximum height on a vertical surface. (Bottom Left) Cat Leap. This technique is used to land on the face of a vertical surface as the hands grab the top of a ledge. (Bottom Right) Downward Stride.This technique is used to execute a one footed jump while descending into the take off. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

This is by no means a common problem in parkour, but due to its severity and the unique risks our discipline presents, we want to offer the solutions we've been using in our own systems to mitigate this injury in the parkour community as it continues to rapidly grow worldwide. We're also seeing a growing demographic of older practitioners, and seeing how age can heighten risk, this may become a larger problem in the coming years if we don't address it early on.

This paper will

- Put forth observations of the pattern of Achilles tears in parkour through collected data
- Identify the most common causes
- Offer solutions to prevent these injuries that can be applied by practitioners, coaches, and program managers

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What Is the Achilles Tendon?^^

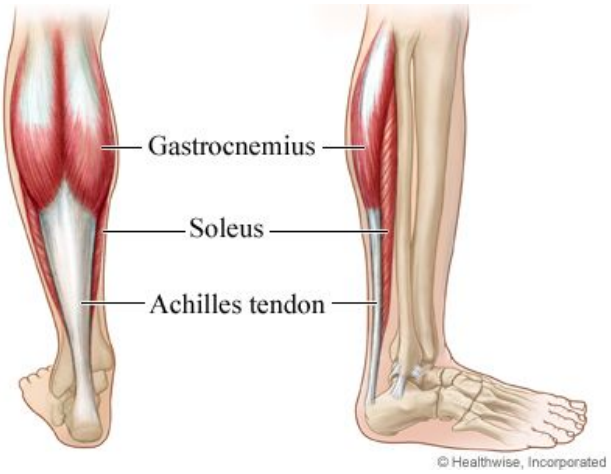

Figure 4. Basic Anatomy of Lower Leg Muscles and Achilles Tendon. Adapted from "Achilles Tendon" by HealthWise Staff. Copyright 1995-2015 HealthWise Incorporated.

Being the largest and strongest tendon in the human body, the Achilles is the tissue at the back of your ankle that stretches from the bones of your heel to the muscles in your calf (Huang, Perry, Soslowsky, 2004; Järvinen et al.,2002). Like all tendons, it's made up of collagen (Silver, Freeman, & Seehra,2003; Wang, 2006). This is why some of the following contributors that disrupt normal collagen functions can increase the risk for injury.

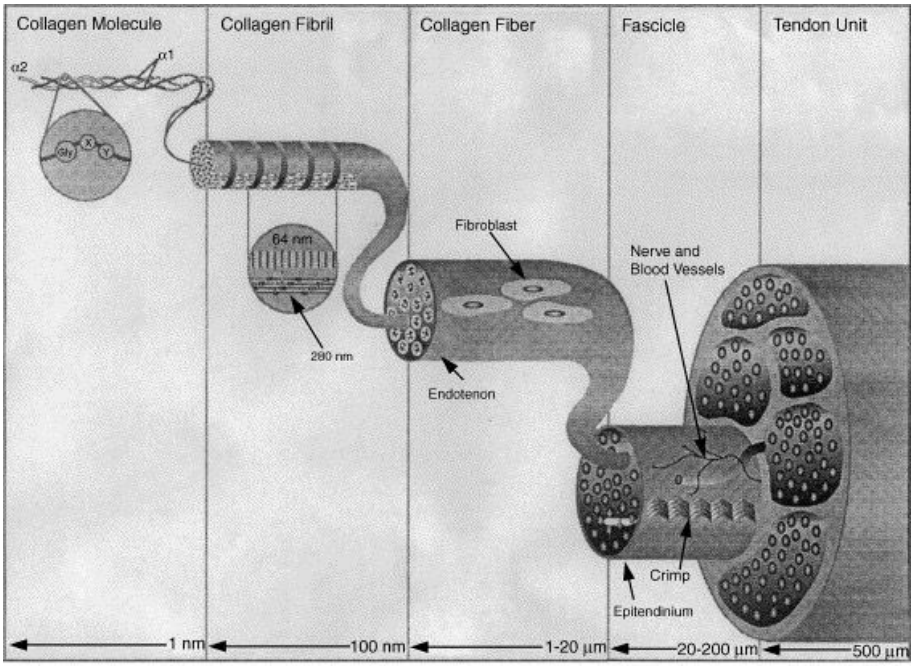

Figure 5. An Illustration Demonstrating the Role of Collagen in the Makeup of the Tendon Unit. . Adapted from "Collagen Self-Assembly and the Development of Tendon Mechanical Properties", by F.H. Silver et al.,2003, *Journal of Biomechanics* 36 (10) p.1532. Copyright 2003 Elsevier Science Ltd.

The Pattern Observed^^

Since around 2010, we have seen reported cases of Achilles tendon injuries from a variety of different places within our community, ranging from some of the most well known parkour facilities to fledgling parkour programs; from beginners to elite practitioners.

Recently, the growing fear even surfaced in one of our fan questions for the first round of the ParkourEDU Podcast, as Eric Rubin asked, “How can we train hard without tearing our Achilles tendons?”

The reason we need to be cautionary in light of this growing pattern in parkour is because many of the sports that are notorious for Achilles tears involve landing and changing directions on flat surfaces, which is a simple position for parkour athletes. In our discipline, many practitioners are attempting to land in technically difficult positions like cat leaps and precisions, and run up walls with maximum output.

On top of that, for those of us who aren’t simply hobbyists, we’re pushing the cusp of what most people had believed was even humanly possible. As we explore this new terrain and reach for our highest potential, we continually add more speed, power, distance. We achieve greater results with more force and elasticity produced through higher tension of the Achilles, but are made to dance that obscure line between max output and injury.

Thus, it will benefit us as a community to start identifying what causes lie hidden and start a dialogue about how to solve these problems, for our own training and systemically through our educational programs.

In our attempt to begin the necessary research, collect data, and search for patterns, we contacted everyone we could discover that has had this unfortunate experience in the context of parkour training. We were able to survey 16 people, but we’re aware of at least 10 more cases of people we were unable to reach. We will continue to collect new cases as they happen and update this paper accordingly.

One of the most prominent patterns our survey revealed is that 5 of 6 of the full ruptures took place during wall runs. This is most likely due to two factors:

1) Wall runs, tic tacs, and their variations can often have a higher peak force because they are one footed at the point of contact compared to two footed techniques like cat leaps, landings, and precisions. All of the full ruptures in our survey took place during one footed contact.

2) On top of the added force from one footed contact, wall runs are also rebounding techniques as opposed to just simply absorbing.

Known Contributors and Their Solutions^^

1. Poor technique
2. Pre-existing conditions / ignored injuries
3. Foregoing a full warm up
4. Poorly targeted focus
5. Unprepared joints, ligaments, tendons
6. Being a man over the age of 30
7. Angled walls and uneven surfaces
8. Poor mobility and flexibility
9. High range of motion in dorsiflexion
10. Overtraining / overuse
11. Plyometric training done for endurance and stamina
12. Extreme physical challenges done as strength training
13. Pharmaceutical drugs
14. The weekend warrior training rhythm
15. Genetic predisposition and disease
16. Overpronation, misalignment, and footwear

1. Poor technique^^

There are some points in particular techniques where mistakes can drastically heighten the risk of an Achilles tear. By knowing where these points exist, safer progressions can be created, injury prevention awareness can be written into curriculum, and other actions can be taken to decrease the probability of these mistakes.

In light of the pattern in our survey, let's take the wall run as an example and look at common errors that can lead to Achilles tears and ankle injuries in general.

Stepping too low on the wall

Your foot should contact the wall roughly around standing hip height.

During a wall run, the center of mass is moving toward the wall in a direction (dotted white line in fig. 6 below) that depends mostly on the jump off the last step on the ground. As the foot contacting the wall drops further below this line of direction, the forces placed on the ankle are amplified exponentially since other joints (the knee and the hips) become less aligned with the direction of the center of mass and the large muscle groups further up the leg have less and less ability to manipulate the forces of changing direction. With lower foot placement on the wall, more stress is directed to the ankle, and the risk of injury increases.

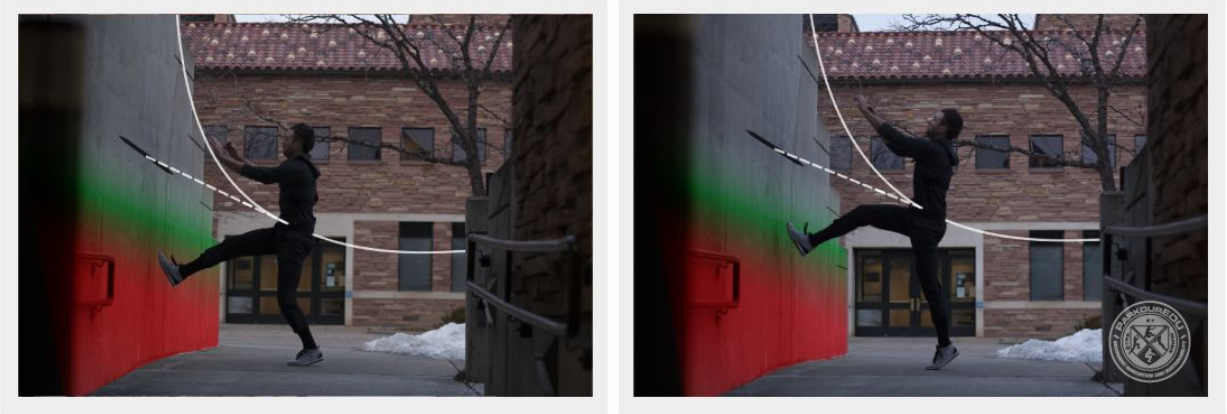

Figure 6. Amos Rendao Demonstrates Proper and Improper Foot Placement on the Wall During a Wall Run. (Left) Improper technique. This step is too low as it is under standing hip height. (Right) Proper technique. This step is around standing hip height. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

Chest angle to the wall

The chest should be slightly leaning back during first contact with the wall. If the chest is angled forward, this changes the location of the center of mass and the curve of the trajectory upwards, putting more stress on the ankle. Leaning back allows a smoother transition upwards and a more ideal angle for the ankle.

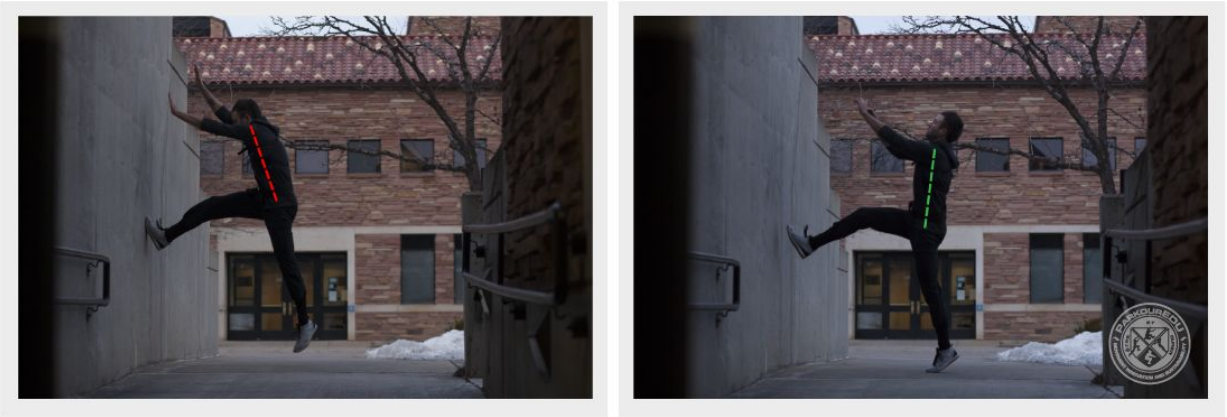

Figure 7. Amos Rendao Demonstrates Proper and Improper Chest Angle to the Wall During a Wall Run. (Left) Improper technique. This chest angle is down and in towards the wall. (Right) Proper technique. This chest angle is slightly open and facing up the wall. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

Not jumping off the last step on the ground

In order to start changing the trajectory upwards before contacting the wall, it's important that the last step on the ground is a jump upwards. This helps smooth out the curve of the change in direction. If the practitioner solely relies on the step on the wall to change direction upwards, the foot on the wall has to take on more force while rebounding, increasing risk of injury.

Taking off too far away from the wall

The last step on the ground should be roughly a leg's length away from the wall (this will slightly vary with increase in speed). Taking off too far from the wall will result in absorbing more so than redirecting the momentum up the wall. This is because as take off distance increases, the amount of upward momentum on wall contact decreases. Also, the ground takeoff point can change the smooth curve of the trajectory upwards as it varies in distance away. At high speeds, this can be extremely stressful on the ankle joint.

Figure 8. Amos Rendao Demonstrates Proper and Improper Takeoff Distance from the Wall During a Wall Run. (Left) Improper technique. This takeoff is much further than a leg's length away from the wall. (Right) Proper technique. This takeoff is roughly a leg's length away from the wall. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

Taking off too close to the wall

On the other extreme, taking off too close can cause a cramped position, making it difficult to get the ideal chest angle and necessary foot height on the wall. It also doesn't allow the takeoff step on the ground to initiate a big enough change in your trajectory for a smooth curve upwards.

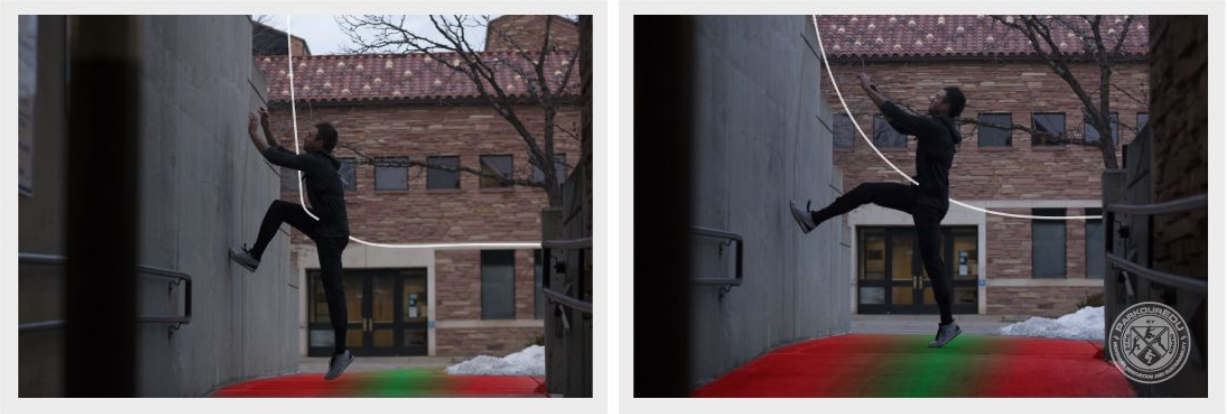

Figure 9. Amos Rendao Demonstrates Proper and Improper Takeoff Distance from the Wall During a Wall Run. (Left) Improper technique. This takeoff is less than a leg's length away from the wall. (Right) Proper technique. This takeoff is roughly a leg's length away from the wall. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

Inactive ankles

"Active ankles" means engaging the muscles around the ankle in order to properly absorb impact, rebound, etc. This is opposed to "inactive ankles" where the muscles are relaxed. Sometimes students haven't developed the correct muscle memory and timing in early progressions or lose focus on keeping their ankles active. More advanced practitioners may be vulnerable to fatigue and momentary loss of focus on keeping the ankles active. This is potentially the worst of all these technique flaws seeing how an inactive ankle leaves the ligaments and tendons to handle the force almost completely alone, putting a lot of stress on the ankle joint.

A combination of common errors

A combination of any of the above can drastically exacerbate the problem as well. For example, 'taking off too far from the wall' mixed with 'stepping too low' could be detrimental. Add 'inactive ankles' to that recipe and you've got an injury without doubt.

> Side note - Interestingly, after I went out to shoot photos and execute multiple reps of all the wrong ways listed above, I felt tightness and soreness in my Achilles, which never happens to me. So I'm definitely not going to get you a photo of a combination of common errors; you're just going to have to use your imagination.

[Insert photo from your imagination here]

The ‘run up restriction’ strategy

In order to lessen the consequences of the above mistakes, we’ve seen great success in using ‘run up restrictions’ in our curriculum for techniques like wall runs, vaults, tic tacs, or anything where overzealous students put too much speed into the run up without control.

This is as easy as marking a starting point for students or simply restricting how many steps they’re allowed to take. As they demonstrate proficiency with each progression, you can then add distance or steps to their run up.

Tic tacs

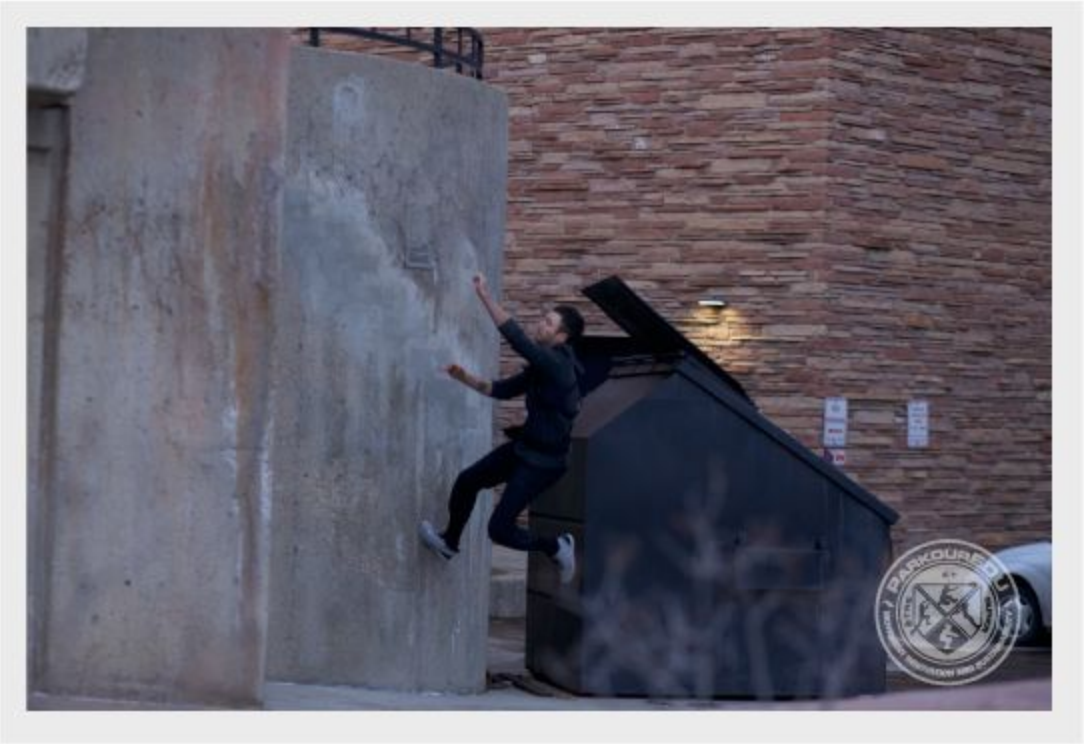

Figure 12. Amos Rendao demonstrates a tic tac. Copyright 2015 by ParkourEDU. Photographer: Rain Duran.

Tic tacs share all the same common errors above that can increase the risk of Achilles tear. They’re even more complex because of the entrance angle being somewhere around 45 degrees rather than straight on as it is with the wall run. I hypothesize that the reason we don’t see the tic tac being a technique pattern for Achilles tears yet is because practitioners often don’t contact the wall with as much speed because of the more complex entrance. We teach tic tacs back to back

with wall runs in our curriculum in order to point out the crossover of common errors that heighten risk of Achilles tears.

2. Pre-existing conditions / ignored injuries^^

The Achilles tendon is the strongest tendon in the human body(Järvinen et al.,2002). It has a tensile strength of 100 megapascals (MPa) (14,504 pounds per square inch [psi]) which almost matches the tensile strength of a femur (bone between the hip and knee) at 121 MPa (17,549.6 psi) (Park & Lakes , 2007). Compare that to most other tendons at around 30 MPa (4,351 psi)(Kongsgaard, Aagaard, Kjaer, & Magnusson, 2005), most rubbers between 10-30 MPa (1,450.4 - 4,351.1 psi) (Chevalier Cleret, 2013) , silver at 170 MPa (24,656.4 psi), , and titanium at 246-370 MPa (35,679.3 - 53,663.9 psi) (Howatson, 2012)**.**

The point is, tearing an Achilles is no easy feat, even when falling victim to multiple contributors. According to most research I've encountered on Achilles tears, one of the most definitive contributors is training on pre-existing conditions and/or injury(Kannus & Józsa, 1991; Klippel, Stone, & White, 2008; Tallon, Maffulli, & Ewen,2001).

In our survey, 31% of the Achilles injuries were preceded by pain, fatigue, or tightness in the Achilles tendon and/or calf muscles in the weeks leading up to the injury.

Solutions for pre-existing conditions / ignored injuries

If you feel pain or tightness in your Achilles during training, immediately stop doing the offending activity. It really sucks to walk away from a challenge you're working on, but it means you'll be back to that challenge in no time with far less risk of injury.
Listen to your body! Give yourself ample time to heal and come back stronger.

> "*It's not a race, there is no rush, no need to be in a hurry. Take your time, you know, it's all about [slow and steady progression].*"
> *- Stephane Vigroux*
> (Personal Communication, February 2016)

Interestingly, pain doesn't always accompany an injured Achilles, so don't just rely on the sensation of pain, tightness, or discomfort. Understanding all the other contributors will give you guidance in avoiding that random snap without warning.

If you are experiencing pain, tightness, or discomfort and you've stopped the offending activity, your work is not done if you're serious about getting back to full health as quickly as possible. However, don't rely on RICE (Rest Ice Compress Elevate) as your definitive solution.

Inflammation may not accompany tendon degeneration (Andres & Murrell, 2008; Kader, Saxena, Movin, & Maffulli, 2002; Rees et al., 2006). Physical therapy, massage, and methods for encouraging blood flow can make a world of difference in getting you back quicker with more range of motion (ROM) and strength. Consult a trusted professional to address your particular situation.

3. Foregoing a full warm up^^

This is probably a no brainer for most educated athletes, but let's also consider the parkour lifestyle and normal training rhythms. It's common that parkour training sessions will go for 3+ hours with breaks to hang out or have a snack. We often have casual group meetups where people go in and out of downtime. Vinny Fiacco tells his full rupture story as not only having a slight pain in the prior days (pre-existing condition / injury), but also after training for an hour and a half, he cooled down, and then didn't warm up a second time before doing a high speed wall run.

For a simple analogy as to what's happening to the Achilles tendon in this situation, you can think of it as putting a rubber band in the freezer, taking it out after a little while, and then making it do a wall run at top speed!! That makes sense right?
But seriously, warming up is important in that it increases the temperature of tissue, reduces muscle viscosity, makes contractions smoother, produces enzymatic enhancement of contraction (Hess, 2010; Leppilahti & Orava, 1998; Park et al., 2011; Safran, Garrett, Seaber, Glisson, & Ribbeck, 1988). Even though the tendon doesn't undergo physiological change, greater muscle ROM allows for less stress on the musculotendinous junction (Safran et al., 1988). Basically, your muscles aren't as tight, and that means less stress on the tendon and where it connects to the muscle.

In our survey, over half the injuries were preceded by either a 'partial' warm up or 'no' warm up at all.

Solutions for warming up

If you forego warming up, it can greatly intensify all of the other contributors and may cause that fatal combination for your Achilles (Leppilahti & Orava, 1998; Safran et al., 1988).
Be thorough with your warm ups, especially at older ages, and don't forget that if you cool down, get a full warm up before jumping back into it.

4. Poorly targeted focus^^

Through isolated techniques, combinations, and improvisation, a practitioner should have a primary focus where they put their conscious attention while all other movements are functioning subconsciously through muscle memory. For example, as a beginner approaches a wall run, an early primary focus is the first step on the wall. They aren't focusing on their breathing or correct running technique. All of that is subconscious and lies in the background of their primary focus.

Good parkour progressions adjust this primary focus in a safe order as the student develops the muscle memory for various elements of each technique.

Throughout progressions, execution of isolated techniques, execution of combinations, and improvisation, the practitioner's primary focus is constantly shifting, usually in just a fraction of a second. This is called a "focus shift." If this focus shift is too early, too late, or the primary focus is poorly placed, the practitioner is far more likely to make crucial mistakes.

Let's once again analyze the wall run as an example. If a beginner student is tasked to grab a ledge 3 meters (9-10 feet) off the ground, they have a small window of time (relative to the speed of their approach) to shift their primary focus from stepping up the wall and then looking up to grab the ledge. It is common for beginners to shift their primary focus up to the ledge far too early. Doing so can cause mistakes like stepping too low on the wall or not keeping the ankle active.

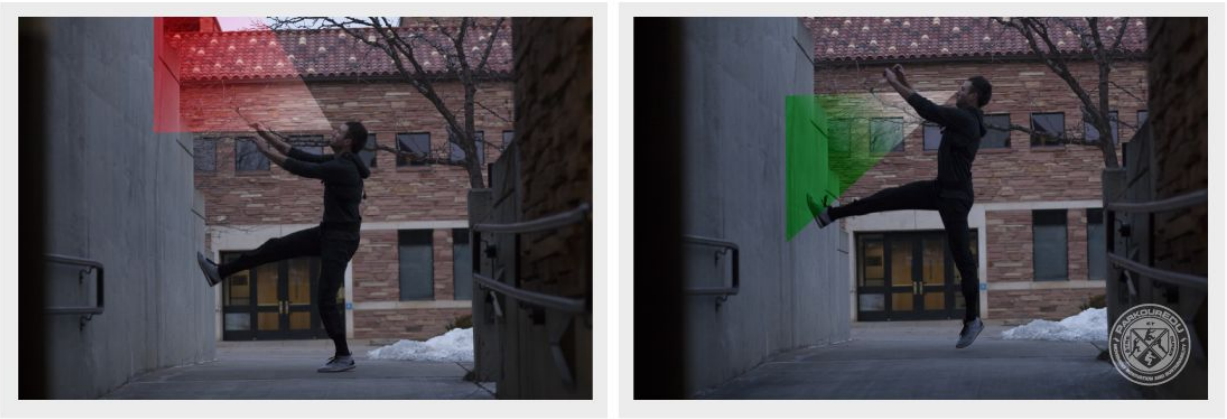

Figure 13. Amos Rendao Demonstrates Proper and Improper Primary Focus During a Wall Run Before Foot Contact on the Wall. (Left) Improper technique. This happens when looking up at the ledge too early and losing focus on good technique during first contact on the wall. (Right) Proper technique. The primary focus is on good technique before shifting focus up to grab the ledge. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

However, it should be noted that the more advanced a practitioner, the more they can get away with earlier focus shifts through proficiency of technique.

Solutions for poorly targeted focus

Through smart progressions, complicated focus shifts can be minimized until the student has enough repetition and comfort with the baseline pieces of the technique or combo.

In the example of the wall run, beginner students can be taught without the end goal of a ledge to grab by having them practice on a wall that is at least 4 meters (around 13 feet) high. This will allow them to dial in the wall run technique with the sole priority of control and quality before the distraction of a ledge to grab.

5. Unprepared joints, ligaments, and tendons^^

With far less vascularization, ligaments and tendons take much longer to strengthen and recover compared to muscle (Low, 2011, p. 224). If your progression is too fast for your tendons, ligaments, and joints to keep up with, you'll naturally struggle with injuries.

Solutions for unprepared joints, ligaments, and tendons

Parkour training has the potential to be high impact, and for practitioners new to the discipline, it should be a priority to integrate joint preparation exercises, avoid extremely high impact movements, and strengthen ligaments and tendons through slow progression.

If you believe you're particularly vulnerable, strengthening the ankle plantar flexors, namely the gastrocnemius and soleus (calf muscles), has been linked to prevention of Achilles rupture (Hess, 2010; Seeley, Stephens, & Tate, 2006). You can do this with variations of calf raise exercises. However, you should avoid adding weight or very strenuous variations unless you're certain you don't already have an injury that would be affected negatively.

Here's some direction on how to do body weight calf raises from "Parkour Strength Training" by Ryan Ford and Ben Musholt:

"To do this movement, stand with your feet shoulder width apart and your weight spread evenly from your heels to your toes. Shift your weight forward and push into the ground so that you rise onto the balls of your feet. Lift as high as you can on your tiptoes and then lower your heels back to the ground" (Ford & Musholt, 2015, p 86).

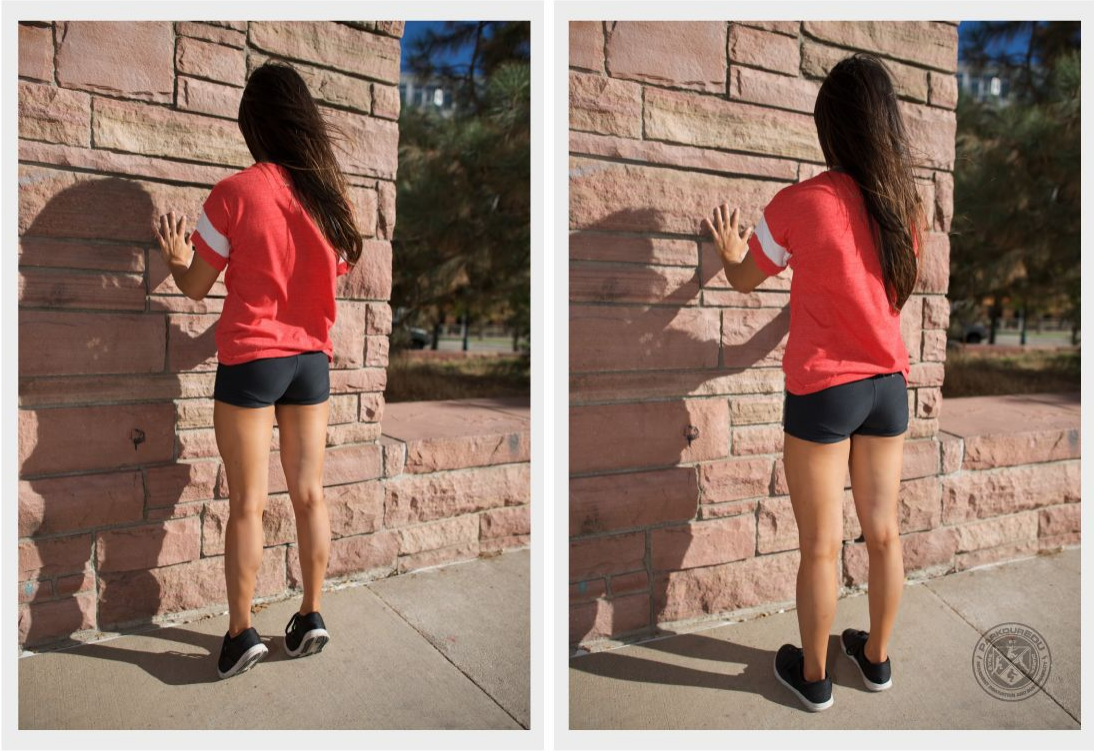

Figure 14. Kira Nguyen Demonstrates Calf Raises. Adapted from *Parkour Strength Training: Overcome Obstacles for Fun and Fitness* (p. 86) by R. Ford and B. Musholt, 2015, Copyright 2015 by BPM Rx, Inc. Photographer: Justin Sikkema.

"[It] is also good to do calf raises with the toes pointing in and out"(Ford & Musholt, 2015, p86).

Figure 15. Kira Nguyen Demonstrates Calf Raises with the Toes Pointing Inward (left) and Toes Pointed Outward (right). Copyright 2015 by BPM Rx, Inc. Photographer: Justin Sikkema.

If this is too easy, add weight or start rebounding with exercises like ankle bounces. Here's another excerpt from Ford and Musholt's book "Parkour Strength Training."

> "An equipment-free alternative to jump rope, ankle bounces help condition the many small bones, ligaments, and soft tissue pads of your feet. They also strengthen your Achilles tendon, which if torn, is a devastating injury. Stand on slightly flexed knees, with your heels lifted from the ground a couple centimeters. Bounce up and down on the

> balls of your feet, rebounding quickly and avoiding heel contact with the ground. Can you do it while moving around in different directions? On one leg instead of two? Real world movement rarely happens under perfect conditions. It's best to prepare for the inevitable" (Ford & Musholt, 2015, p86).

Here's a video example of the above description:

Ankle Bounces (Ford, 2014)

6. Being a man over the age of 30^^

If you haven't crossed this line, stop aging now. Research Peter Pan / Lost Boys.

...but seriously, tendon degeneration naturally comes with age, and studies show that Achilles injuries are more common in males than females (Joseph et al., 2014; Kvist, 1994; Strocchi et al., 1991). This may be due in part to a higher participation rate in sports for males, but differences in tendon mechanics, such as greater elongation and less stiffness, suggest a potential protective mechanism that would explain why women have lower rates of Achilles tendinopathy (Joseph et al., 2014).

Most sources draw the line for heightened risk around 30 years of age (Gravelee, Hatch, & Galea, 2000; Longo, Petrilo, Maffulli, & Denaro, 2013; Mazzone & McCue, 2002), but my hypothesis is that because our discipline can involve high impact in complicated positions (e.g. wall runs and cat leaps), we'll see a lower average age. Our survey demonstrates this possibility by having the youngest person at 17, the average age at 28, and the median age at 26. However, it should be recognized that this could simply be a correlation to the present demographics in parkour (mostly younger males).

Solutions for being a man over the age of 30

While there may be many aging factors we cannot presently control, we can avoid certain things that will increase the speed of degeneration like nutrient deficiencies and altered hormone levels, whether due to poor diet, use of particular drugs, etc. (Maffulli et al., 2005, p. 29).

Inactivity is a cause of tendon degeneration, so having a lifestyle of regular exercise is an important preventative measure (Maffulli, Renström, & Leadbetter, 2005, p. 29).

If you are older than 30, you should take extra precaution with slower progressions and ample recovery time. Although it's annoying to look over at young ones repping maximum output

techniques over and over without even warming up, that can't be your life anymore … just stare at them with condescending eyes as you dwell on the fact that it will catch up with them eventually … or view your progression with parkour as a personal journey and not a race, right?

7. Angled walls and uneven surfaces^^

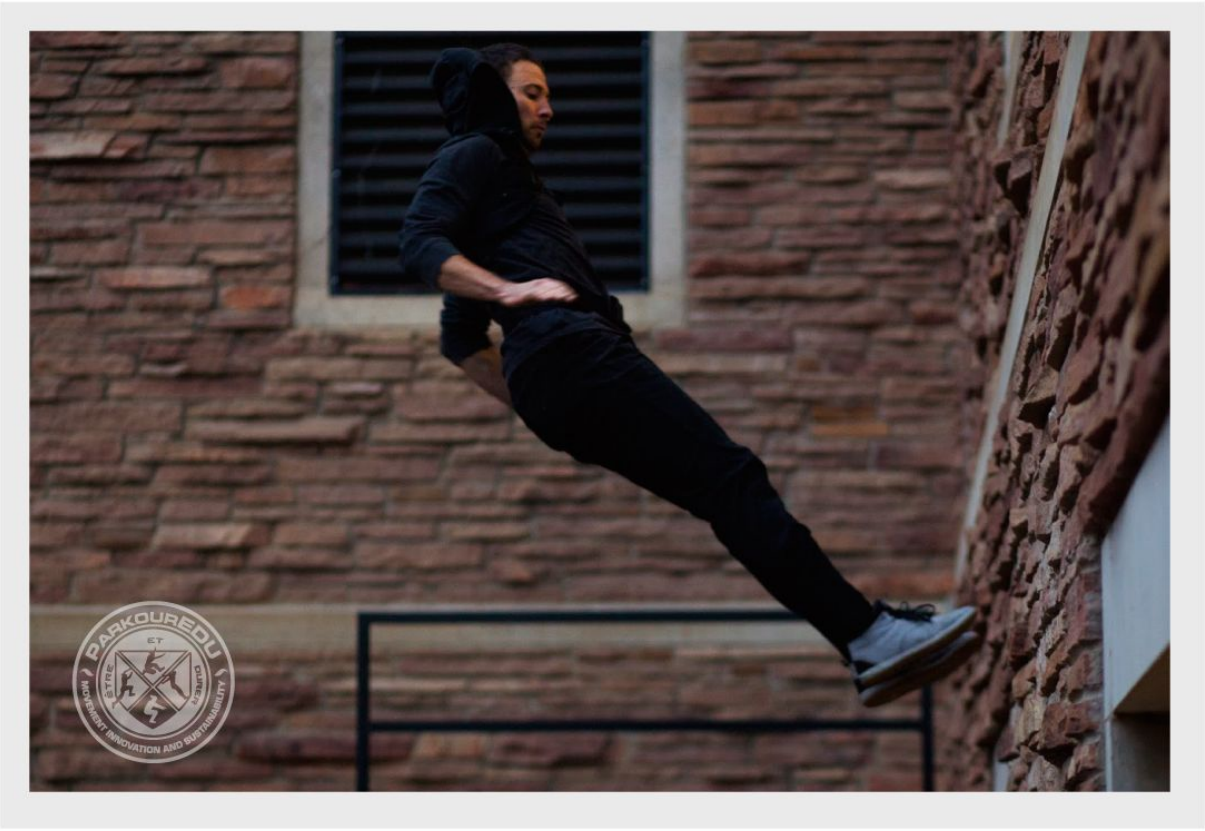

Figure 16. Amos Rendao Demonstrates a Cat Leap onto an Uneven Surface. Copyright 2015 by ParkourEDU. Photographer: Rain Duran. Graphic Designer: Brandon Douglass

It's a no brainer to be extra cautious while putting max output into a step off an oddly shaped boulder or executing a high impact landing onto an uneven tree trunk. However, there's a shape that may disarm you because of it's seemingly simple appearance: the obtuse, angled wall. There's an emerging trend of Achilles ruptures and close calls that are taking place on these walls (including the Warped Wall, a Ninja Warrior obstacle). Although we were unable to collect any data specific to this, we have heard reports of at least seven Achilles tears due to Warped Wall training.

I have my own hypothesis about this due to stories from others and a personal non-injury experience. I was chasing a little kid up an obtuse, angled wall (he called me a mean name), and

I had a little scare as I compressed my ankle and felt a lot of force on my Achilles. I believe it was due to the fact that I'm so accustomed to the ingrained muscle memory of running up the most common flat wall shape at 90 degrees. What the scare felt like was a muscle misfire making my ankle feel inactive, where the contact with the angled wall came just a fraction of a second behind the predicted wall contact. Ryan Ford also had a similar experience on the show American Ninja Warrior where he sprained his ankle on the first step of the warped wall. He told me that his experience and hypothesis was just as I described for mine (personal communication, 2015).

My hypothesis is that some practitioners are missing the timing due to muscle memory geared for the most common 90 degree, vertical wall. However, we don't have much data behind this at the moment, so just keep this in mind as we further study this dynamic.

As far as odd or uneven surfaces, 25% of our survey participants had their injury take place on surfaces like boulders, wood chips, or uneven vertical walls.

Solutions for angled walls and uneven surfaces

Take caution on extremely technical surfaces compared to the simple flat surfaces and 90 degree angles most practitioners are accustomed to. The obtuse, angled wall pattern is still emerging, so please contribute any information you may have in the comments. For long term preparation, get out in nature and start slowly progressing on shapes that will prepare your body for complexity and make all those simpler urban shapes much easier to navigate.

8. Poor mobility and flexibility^^

Mobility is the ability to *actively* move through a particular ROM. Flexibility, on the other hand, is the ability to *passively* achieve ROM.

Mobility and flexibility are integral pieces of your movement training. In my experience with the parkour community, these areas are far more neglected compared to strength, power, technique, mental fortitude, etc.

When you lack mobility, you have less ROM in a given joint. This means you'll have to absorb impact in less time. Once you've reached the end of your ROM, the force must go somewhere else. If there's no other technique (such as a roll) to distribute the force, the remainder can tear muscles, break bones, rip ligaments, etc.

A particularly important ROM for Achilles tear prevention is dorsiflexion (DF). This involves bringing your toes towards your shin.

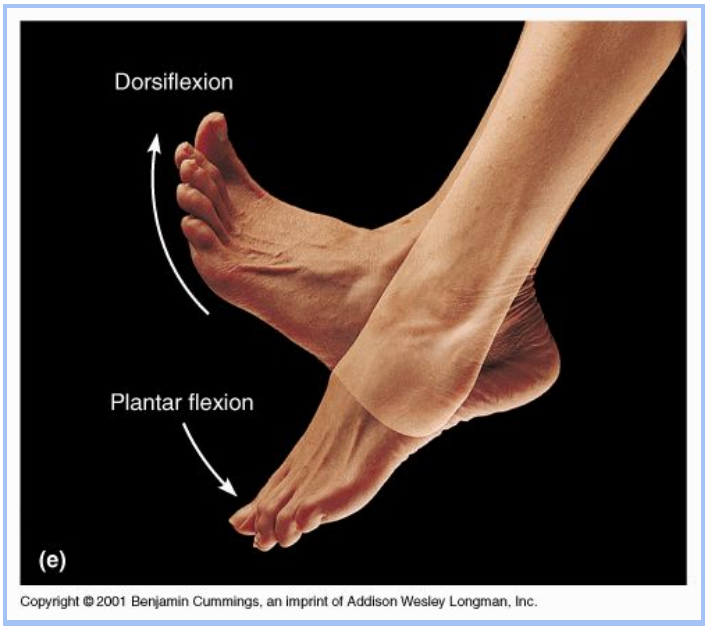

Figure 17. Demonstration of Dorsiflexion and Plantar Flexion. Adapted from "A Guide to Anatomical Terms of Location and Movement for the Runner" [Web Blog] by John Davis. Copyright 2001 Benjamin Cummings, an Imprint of Addison Wesley Longman, Inc.

Even if it isn't an acute injury that is immediately apparent, practitioners with a smaller DF ROM may be more likely to regularly overload their plantar flexor muscle-tendon units which could heighten the risk of Achilles tendinopathy (Kvist, 1994; Whitting, Steele, McGhee, & Munro, 2011). Basically, having poor mobility and flexibility could lead to the pre-existing conditions for Achilles tears, if not just simply bothering you with chronic pain and other compensation problems.

Solutions for mobility and flexibility issues

You can test your DF to see if you have an ideal ROM. In order to do this at home, check out this excerpt from "Parkour Strength Training":

> "Single Leg Ankle Dorsiflexion Test (also known as the wall dorsiflexion test)
>
> 1. Prepare for this test by finding a tape measure and a wall.
> 2. For accurate results, you should also go barefoot because doing it in shoes can give inaccurate results.
> 3. Stand on one leg facing the wall with your front leg's toes pointing straight at the wall and your back leg's knee pointed at the ground.

4. Try to touch your front knee to the wall without letting your heel come off the ground.
5. If you were successful with the previous step, move your toes a little bit farther away from the wall and try again. When you can no longer do this test successfully, record your last successful distance as your score for that foot.
6. Switch feet and repeat the previous steps until you have a score for both feet.

Rating System (rate each foot independently):
Poor: 0-2 inches.
Fair: 2-4 inches.
Good: 4-5 inches.
Great: 5+ inches" (Ford & Musholt, 2015, p 81).

Disclaimer: this method is not perfect, but because most people don't have access to a digital inclinometer, it's the most reliable and accessible method (Konor, Morton, Eckerson, & Grindstaff, 2012).

Now that you have an idea of what your DF is like, here are some methods on developing more mobility if you need it.

Mashing

The purpose here is to gain a bit of extra temporary ROM during your warm up so that you can use it in your training session. This process helps you to perform better in your session and also re-educate your body to use more ROM. Outside of this re-education, mashing is a temporary fix and does not have long term effects.

You can use things like foam rollers, lacrosse balls, or hand rails (my personal favorite) to mash your calf muscles, Achilles, and plantar fascia (the bottom of your foot).

Try Kelly Starret's approach to mashing the Achilles and calf muscles in this short video: Protect those heel chord man! (Starrett, 2011).

Mobility

Here's a video from Caleb Iuliano on ankle joint preparation that Ryan Ford endorses as a great mobility drill with variations:
Ankle Impingement aka Ankle Thingy Prehab/Rehab Guide (Iuliano, 2013)

Flexibility

For flexibility, you can use these calf stretch variations:

> "There are many positions that can be used to stretch your calf, but the basic idea is to hang out in such a way that you bring your shin closer to the top of your foot. Placing your toes on the edge of a stair and letting your heel drop lower is one technique …. You should be sure to vary between straight and flexed knee ankle DF in order to stretch both layers of calf muscle. Your gastrocnemius is the larger, more superficial muscle of your calf and it is best stretched when your knee is straight. Your soleus is the smaller, deeper calf muscle and it is targeted better with bent-knee DF. If you don't utilize both bent and straight leg variations, you won't be making the best possible gains" (Ford & Musholt, 2015, p54).

Figure 18. Kira Nguyen Demonstrates a Bent Leg Heel Drop. Adapted from *Parkour Strength Training: Overcome Obstacles for Fun and Fitness* (p. 78) by R. Ford and B. Musholt, 2015, Copyright 2015 by BPM Rx, Inc. (Left) Straight leg variation. (Right) Bent leg variation. Photographer: Justin Sikkema.

> "Similarly, keeping your foot flat on the floor, while driving backward through your heel and leaning your body forward into a wall — as with a runner's stretch — is another."(Ford & Musholt, 2015, p54).

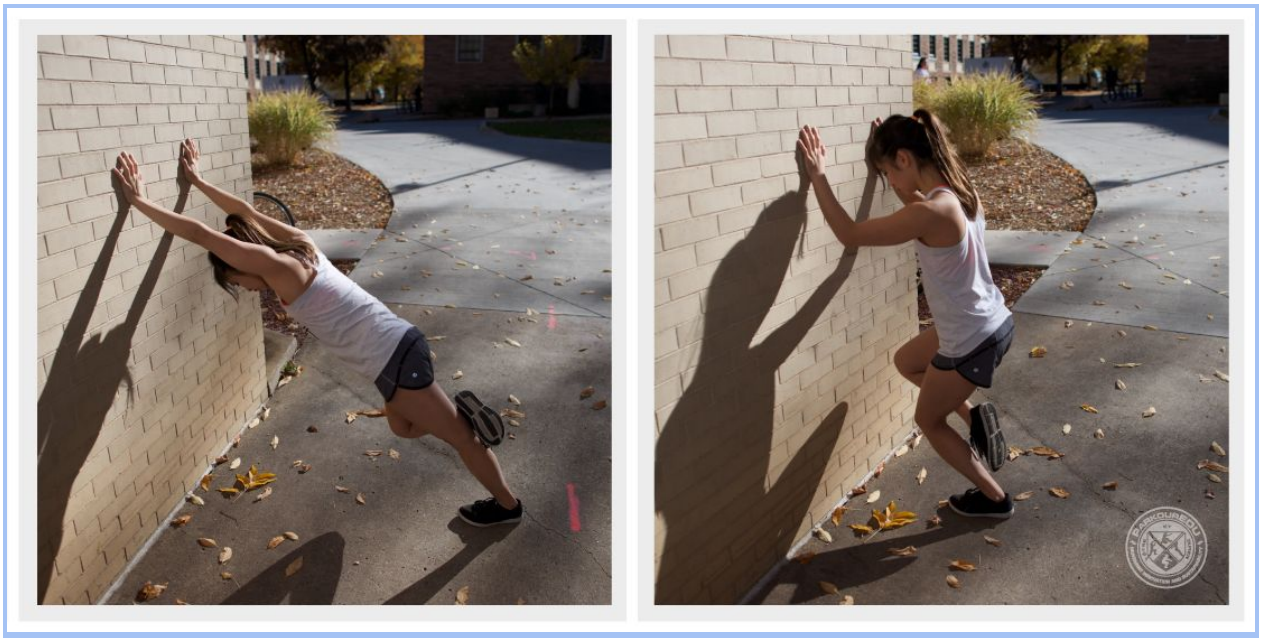

Figure 19. Kira Nguyen Demonstrates Two Calf Stretch Variations. Adapted from *Parkour Strength Training: Overcome Obstacles for Fun and Fitness* (p. 54) by R. Ford and B. Musholt, 2015, Copyright 2015 by BPM Rx, Inc. (Left) Straight leg variation. (Right) Bent leg variation. Photographer: Justin Sikkema.

> "Loading your calf with additional bodyweight is highly effective too, and you can do it either from a low lunge or a squat position. The goal is to use your hands to apply pressure on your leg, in order to drive your ankle into greater DF. Put both hands on the end of one thigh, just above your knee, and push along an angle to drive the knee over your foot. Be sure to keep your heel glued to the floor. Oscillate in and out of the stretch to see if you can take your ankle into a deeper position" (Ford & Musholt, 2015, p54).

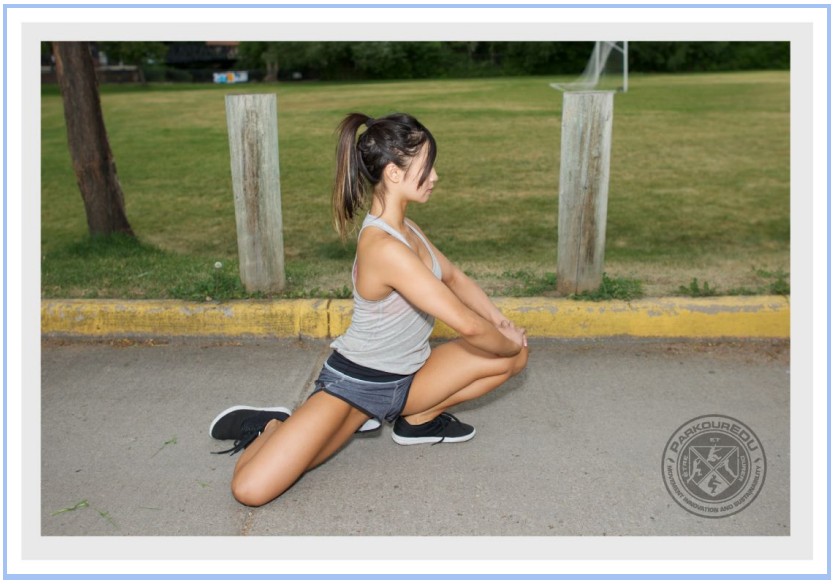

Figure 20. Kira Nguyen Demonstrates a Calf Stretch Variation from a Lunge. Copyright 2015 by BPM Rx, Inc. Photographer: Justin Sikkema.

9. High range of motion in dorsiflexion^^

Now before you start going crazy on mobility and flexibility to get your DF ROM flying off the stoked-o-meter, studies have found that excessive DF with poor calf strength could be a major culprit (Mahieu, Witvrouw, Stevens, Van Tiggelen, & Roget, 2006; Van Ginckl et al., 2009). This is relative to your particular movement goals, so it's complicated, but we're identifying a pattern of high DF in practitioners that have had full ruptures. Vinny Fiacco, Rene Scavington, Rafe Kelley, and a few others all have above average DF.

Solutions for high range of motion in dorsiflexion

If you find that your DF is already really good, make sure you have the calf strength in the extreme end range to support it.

10. Overtraining / Overuse^^

For all the complete fanatics out there, bridling our deepest love is a difficult challenge, but overtraining has real consequences. The stressed collagen is not repaired correctly, the fibers become disorganized, and with ongoing stress of the tendon, the body is unable to repair the tissue and damage is done (Tallon et al.,2001). The scary thing here is that you may not experience any symptoms at all (Tallon et al.,2001).

Rene Scavington (undoubtedly a parkour fanatic and founder of Origins Parkour) spoke about his Achilles rupture in STS Episode 5, "During that session, I probably did 40 to 50 tic tacs of the same nature [the two step 180 variation], using the same technique, and it didn't snap." He also stated online "I was hitting the wall quite hard on a side I don't train." (Scavington, 2015b) Lastly, in an injury summary video he said, "...I was putting a lot of pressure on myself to get better at parkour. Again, I was feeling a lot of success, and anytime you feel success, for me it's like keep getting better, keep getting better, keep getting better, and I wasn't giving myself a lot of time off; a lot of time to take breaks."

However, it's possible fatigue and pre-existing conditions/injury may have played a large role as well as he writes, "I will admit to some discomfort on [the injured side] in my training this week, …"(Scavington, 2015b) He also stated, "Before too, I was dealing with jumper's knee on this leg [points to knee on the same side as Achilles injury]. So, I was already starting to fall apart a bit" (Scavington, 2015c).

Lastly, do keep in mind he also highlighted factors like a shift from more general training to specialized training and an 8 week shock training program preceding the injury (Scavington, 2015c).

Because Rene has been such a champ about documenting the experience, I've followed him closely as he has put out various analyses. For more perspective, his injury summary video can be found here (Scavington, 2015a). My tentative synopsis is that the largest contributors acting in combination were:

1) Overtraining
    a. Not enough rest and recovery
    b. High reps of high impact on a side he doesn't train and thus it wasn't as conditioned as the other side
    c. Coming off of an 8 week shock training program
2) Technique error (both of which lead to an extreme range of dorsiflexion)
    a. Taking off too far away from the wall
    b. Contacting the wall with a straight leg vs. slight knee bend along with his good DF ROM

Solutions for overtraining / overuse

Rene's case is not clear cut and surely involves a combination of many other contributors that, although not as substantial, can compound the risk. Because overtraining is relative from person to person, there is no formula to follow. But if you're learning a new movement like a wall run (or even six years into your training finding a new addiction to maximizing your wall run), you'll have to consider the fact that your body needs time to adjust to repeated high stress through a slow conditioning process. Make sure you're getting enough rest in between higher impact training sessions and/or taking high reps on a specific technique down a bit. Ultimately though, this is a difficult thing to gauge and will have to remain a personal pursuit. Listen to your body!

From a coach or program designer's perspective, it's important that you write your curriculum and programming accordingly (so yeah, you're going to have to remove the 50 wall run vertical max reps followed by 12 bounding box jumps superset workout from class #1 of your Intro to Parkour program).

11. Plyometric training done for endurance and stamina^^

Does anyone remember CrossFit's Achilles genocide?(Beastmodal Domains, 2011; Beers, 2011; Chung, 2013; CrossFit Mike,2011; Goldkuhle,2010; Holiday, 2011; Kunz, 2011; McCarty, n.d.; Nicokie, 2011; Pope, 2012; Q, 2001; Rawlings, 2011; Starrett, 2011; Toledo, 2012; Vandelden, 2012; Wilson, 2011; Zumwalt, 2015) Basically, the bounding box jump, which was being encouraged at high reps with a plyometric transition at the bottom, was claiming hundreds of victims until CrossFit HQ finally altered the parameters for this particular exercise in their

prescribed WODs (workout of the day) (Chung, 2013). To be fair, it would be important to compare the amount of Achilles injuries to the amount of CrossFitters doing these particular workouts and the sheer amount of box jumps performed over this time range. However, many CrossFitters use the step down method instead of the bounding method, and thus I was unable to find any clear data comparing Achilles injuries with the bounding technique in particular. It should be noted that more than a few major CrossFit gyms have banned bounding box jumps in their programs.

High rep plyometric training doesn't mean certain Achilles death, but it can heighten risk of injury if paired with poor technique, bad programming, muscle fatigue, overtraining, etc. Plus, we all know that jumping up and down on a box until we can't see straight is not only boring, but parkour athletes are demonstrating more and more everyday that we have forged huge jumping power, soft landings from heights, and truly functional capabilities through our methods of play, scientific approach to healthy biomechanics, power development through weightlifting and plyometrics, and by simply doing the actual movements we want to be good at without exceeding a safe volume.

Solutions for plyometric training done for endurance and stamina

Spread awareness and caution to athletes who are dead set on this style of high rep plyometric training. Make sure, as a coach and practitioner, quantity is never put above quality of repetitions.

12. Extreme physical challenges done as strength training^^

Hey, you think you can do a 1,000 muscle ups in 12 hours? Wanna do 500 backflips tomorrow to raise money for a good cause? If we're going to be serious about our training, let's do 100 precisions in a row, and if you miss one, you have to start over. We're not going home until we all complete it together.

These challenges are not inherently bad approaches to training, but please don't be misled into thinking that they are effective strength training methods and don't come with a risk to your physical health. This sort of training has its benefits in building mental fortitude, forming strong bonds between those who struggle together, finding one's physical limits to better know oneself, forging a warrior's spirit, etc. but don't forget that all of this may increase your risk of injury.

While I was recently in Europe on the shoot of an upcoming documentary, we met up with Chris "Blane" Rowat of Parkour Generations, who successfully completed the challenge of 1,000 muscle ups in one day. When we asked him about his experience he recounted, "[After the 1,000 muscle ups], I had inflammation of both elbows on the inside here, at the bicep tendon. They

were so inflamed that I could see the tendon through the skin. It was bright red on both sides. So obviously I knew it was a very extreme experience, but I think those extreme experiences are worthwhile if you prepare to have the recovery process afterwards, and if you've had a suitable build up beforehand" (personal interview, May 11, 2015).

We've heard of cases over the years where practitioners who often take part in this type of training suffer acute and chronic injuries. It makes sense, when you're in the mental fog of these extreme challenges and your body is incredibly fatigued, it drastically increases the probability that the quality of your repetitions will go down. Poor quality under heightened stress increases risk of injury. Mix in another contributor from this paper, and you're looking at a high probability of injury.

Solutions for extreme physical challenges done as strength training

This is extremely personal and relative to your desired goals in life; relative to who you want to be and at what cost. The only solution I can offer for now is the awareness that these can be unsafe methods of parkour strength training. As long as you know this going into them with some alternative goal to develop mental fortitude or camaraderie, you may be able to be more intelligent about how you balance the pushing of your limits. If you do chose to participate in these sorts of challenges, please take Chris Rowat's solid advice: preparation beforehand, listen to your body during, plan for recovery afterwards.

13. Pharmaceutical drugs^^

Fluoroquinolones

Fluoroquinolones are antimicrobial agents that are used to treat Urinary Tract Infections (UTIs), Bacterial Prostatitis, Sexually Transmitted Infections (STI's), Gastrointestinal Infections, Respiratory Tract Infections, Bone and Joint Infections, and Skin and Soft-Tissue Infections (Hooper & Wolfson, 1991). Some examples would be Cipro, Cipro XR, Proquin XR, Levaquin, Floxin, Noroxin, Avelox, Factive, Noroxin, Maxaquin, Tequin, and marketed generics.

These drugs have been implicated in the etiology of Achilles tendinitis and subsequent tendon rupture, and some studies conclude that they triple your risk of Achilles tendon rupture (McGarvey, Singh, & Trevino, 1996; Sode, Obel, Hallas, & Lassen, 2007). The FDA even required black-box warnings because they found that fluoroquinolones are associated with an increased risk in tendinitis and tendon rupture (U.S. Food and Drug Administration, 2008). The scary thing with fluoroquinolones is that they can put you at risk as quickly as a couple hours,

keeping you at risk for as long as 6 months after stopping treatment (Khaliq & Zhanel, 2003; Kim, 2010; Lewis & Cook, 2014)! We did have one survey participant who was taking Cipro.

Corticosteroids

Corticosteroids are any of the steroid hormones, such as cortisol or aldosterone, produced by the cortex of the adrenal gland. Corticosteroids are also produced synthetically for medicinal purposes ("Corticosteroid", n.d.). They are most commonly used to treat Rheumatological Disorders, Respiratory Diseases and Disorders, Allergies and Anaphylaxis, Endocrine and Metabolic Disorders, Blood Disorders, Gastrointestinal Diseases, Liver Diseases, Infections, Neurological and Muscular Diseases, Renal Diseases, Cardiovascular Disorders, Skin Diseases, and Ophthalmic uses (Kirby, 1989).

According to research done by Chan and Fu, (2009), "There is no doubt that the adverse effect of corticosteroids on tendon cells would affect the healing responses to degenerative injuries, corticosteroid injection should be considered as a last resort with careful control on the dosages"(p.23). It's been shown that high levels of corticosteroids inhibit the production of new collagen, prohibiting the tendon's ability to heal (Maffulli et al., p.29). From our research, the adverse effects of corticosteroid use come specifically from injections (Khan, Maffulli, Coleman, Cook, & Taunton, 1998; Speed, 2001). However, even with conclusions like these, injections are still being given out in many sports clinics (Chan & Fu, 2009).

With the risks of tendon rupture for several weeks following the injection, there are also mixed results on whether they are even effective in relieving the pain of tendinopathy(Khan, Cook, Kannus, Maffulli, & Bonar, 2002; Klippel et al., 2008; Shrier, Matheson, & Kohl III, 1996). If this is necessary for you, please do further research and consider alternatives with your medical care provider, like eradicating nerves and fortifying your Achilles with metal rod piercings…

Figure 21.Image of Body Modification Piercings to the Achilles Tendon. Adapted from "Achilles Heel Piercing - Just One Step Too Far?" [Web Log] by A. Maricoda, 2014, Huffington Post United Kingdom, The Blog

...just kidding.

Nonsteroidal Anti-inflammatory Drugs (NSAIDs) - ibuprofen, naproxen, piroxicam, celecoxib, valdecoxib, aspirin, etc.

NSAIDs are any of a group of drugs having antipyretic, analgesic, and antiinflammatory effects. They counteract or reduce inflammation by inhibiting cyclooxygenase, the enzyme responsible for prostaglandin synthesis. NSAIDs may be indicated in the treatment of mild-to-moderate pain, rheumatoid arthritis, osteoarthritis, ankylosing spondylosis, gouty arthritis, fever, nonrheumatic inflammation, and dysmenorrhea. Classic examples include aspirin, ibuprofen, and ketoprofen ("Nonsteroidal antiinflammatory drug", n.d.).

Studies are showing that NSAIDs (with the exception of ibuprofen) can inhibit tendon healing by decreasing collagen content, and once again, there's limited evidence of short term pain relief (Ferry, Dahners, Afshar, & Weinhold, 2007; Khan et al., 2002). For NSAIDS , Chan and Fu's study concluded that, "Further investigation is urgently needed to disseminate the double-edged

properties of prostaglandins in tendon healing before we could advocate the use of NSAIDs for chronic or acute tendon injuries"(p.2).
And more so, it's common knowledge for many athletes that using anti-inflammatory pain relievers can mask symptoms, not allowing the practitioner to listen to their body and make smart training decisions.

Oral Contraceptives

Oral contraceptives are a compound, usually hormonal, taken orally in order to block ovulation and prevent the occurrence of pregnancy ("Oral contraceptive",n.d.).
It seems there's a lack of solid research on the effects of contraceptives on tendons, but one study found that some oral contraceptives have a detrimental effect on collagen synthesis for bones, tendon, and muscle connective tissue (Hansen et al., 2009). Ask your medical caretaker about your oral contraceptive or look into alternative, non hormonal forms of birth control.

Statins
(such as lovastatin and simvastatin)

Statins are a class of drugs commonly used to lower LDL cholesterol levels ("Statins",n.d.).

Statin use is appearing to be associated with adverse effects on tendons, and particularly in physically active individuals (Beri, Dwamena, & Dwamena, 2009; Esenkaya & Unay, 2011; Mansi, Frei, Pugh, Makris, & Mortensen, 2013).

Solutions for pharmaceutical drugs
Awareness. Avoidance of culprits when possible. Extreme caution if necessary.

14. The weekend warrior training rhythm^^

A weekend warrior can be defined as a person who participates in a usually physically strenuous activity only on weekends or part-time (Weekend warrior,n.d.).

Even though you might be getting away with the classic spandex-weekend-bike-a-thon, this is not an ideal way to approach parkour training. Even if you're not going H.A.M. and high impact, studies are showing that you're at a heightened risk for injury (Leppilahti & Orava, 1998; Longo et al., 2013).

Solutions for weekend warriors

If you're extremely strapped for time, at least get a couple short active recovery and basic technique training sessions in throughout your week in order to combat deconditioning. If things are really out of hand for your lifestyle, look for some creative ways to bring exercise to your computer work or other time consuming responsibilities.

15. Genetic predisposition and disease^^

You may be predisposed to injuries such as tendon rupture due to genetics or disease. Scope the following table to see if this is something that may apply to you.

TABLE 1. Systemic diseases affecting tendon

Disease	Structural defect or effect on tendon
Inherited disorders	
Ochronosis (homocystinuria)	Deficient collagen and elastin cross-linking
Aspartylglycosaminuria (AGU)	Abnormal collagen/deficient cross-linking?
Haemochromatosis	Accumulation of iron in matrix
Menkes kinky hair syndrome	Defect in collagen and elastin cross-linking
Mucopolysaccharidoses	Abnormal collagen fibrils, increased GAG
Marfan syndrome	Abnormal fibril structure
Ehlers–Danlos syndromes	Various defects in collagen processing and structure
Osteogenesis imperfecta	Genetic defects in type I collagen
Lipid storage diseases	Xanthomas: slow growing lipid deposits
Myopathies and dystrophies	Abnormal fibril structure
Endocrine and metabolic diseases	
Diabetes mellitus	Increased glycation and cross-linking of collagen
Adrenal disorders	Altered collagen metabolism
Thyroid disorders	Calcification and accumulation of deposits
Amyloidosis	Accumulation of deposits between fibrils
Renal disease	Elastosis, destruction of collagen fibres
Rheumatological diseases	
Rheumatoid arthritis	Destruction of collagen: inflammatory infiltrate
Spondylarthropathies	Inflammation at insertion, fibrosis and calcification
Reactive arthritis	Inflammation at insertion
Reiter's syndrome	Inflammation at insertion
Gout	Urate crystal deposits and inflammation
Pseudogout	Calcium pyrophosphate deposits and inflammation

Table 1. Systemic Diseases Affecting Tendon. Adapted from "The Pathogenesis of Tendinopathy A Molecular Perspective," by G. Riley, 2004, *Oxford Journal Rheumatology, 43(2)* p.131. Copyright 2004 Oxford University Press.

Solutions for genetic predisposition and disease

The first step is having the awareness that your genetic predisposition or disease puts you at risk. The second step is learning how to cope by being cautious with your circumstances or finding out how to overcome them through various physical therapies, diet structuring, etc.
Use the above table's source as a starting point for your research and contact a trusted professional for further advice.

If all your effort still leaves you with present limitations, remember that parkour is an infinite discipline. Just because you can't run high speed at a wall or take high impact cat leaps doesn't mean you'll exhaust the infinite possibilities of lower impact, esoteric challenges and movements.

16. Overpronation, misalignment, and footwear^^

Pronation is rotation of the medial bones in the midtarsal region of the foot inward and downward so that the foot tends to come down on its inner margin ("Pronation", n.d.). … Yeah, I know … just look at the following picture:

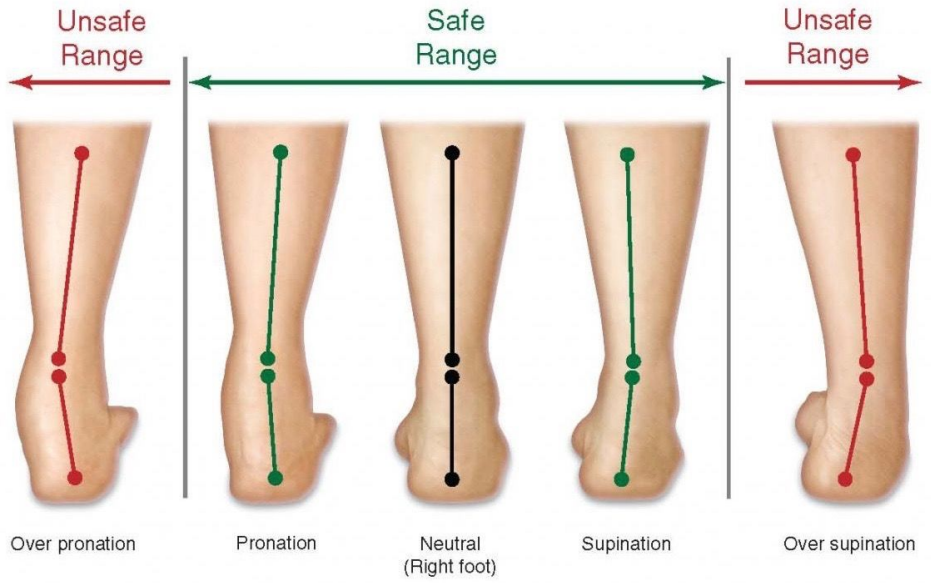

Figure 22. Demonstration of Pronation and Supination. Adapted from "What Runners Should Know About Overpronation and Underpronation" [Web Log] by Laura Norris. Copyright 2010 Body Scientific International.

Studies show that overpronation of the ankle joint and misalignment of the lower extremities can be predisposing factors for Achilles overuse injuries (Clement, Taunton, & Smart, 1984; Galloway, Jokl, & Dayton, 1992; Kvist, 1994; Schepsis, Jones, & Haas, 2002).

Footwear is a factor to consider as well. Shoes with raised heels can cause overpronation and shorten the Achilles (Csapo, Maganaris, Seynnes, & Narici, 2010; Nigg, & Morlock, 1987). And along with flat-footedness, Achilles tendon contracture (a shortened Achilles) can cause misalignment, a contributor to Achilles injury (Arangio, Rogman, & Reed, 2009).

Solutions for overpronation, misalignment, and footwear

Overpronation and misalignment of the lower extremities is not something most people can self-diagnose. Ask a trusted professional for an analysis.

If you start experiencing a pattern of ankle pain, tightness, or discomfort after switching to a new shoe, pay close attention and conduct your own experiments to find out if the shoe in question is the cause.

Conclusion^^

Although the Achilles tear is not pervasive in parkour at this time, it's a devastating injury that can be mitigated. As coaches and gym owners, it is our responsibility to study these factors and apply what we're learning to our curriculum, gym design, and policies. While making sure higher risk groups (practitioners over 30) are aware of this injury and the techniques that most often cause it, you should avoid regular fear mongering of this rare injury and instead intertwine the solutions into your systems and curriculum.

It is my hope that I have contributed more perspective on this matter so that you can bring this information to your own training, your classes, and your business. It is much appreciated if you contribute your constructive criticism, your support, or further leads in the comments below in order to help readers understand this topic better.

Please share this article with your coaches, gym owners, training partners, students, and anyone else you think can benefit from it or contribute more perspective. And please feel free to join the discussion in the comments below.

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